

WHAT IS CLAIMED IS:

1. A method of generating digital data for transmission in a communications system,

the method comprising:

5 determining a digital value for a signal to be transmitted;

determining an amplitude for each sample in a series of samples by combining the digital value with a truncated impulse response, the truncated impulse response

corresponding to the square root of a frequency domain response wherein the frequency domain response meets the Nyquist criteria and wherein the square root of the frequency

10 domain response has a first derivative that is continuous over all points; and

generating a transmit signal with a time-varying amplitude based on the series of samples, the transmit signal having a non-infinite time duration.

2. The method of claim 1 wherein the frequency domain response includes a

15 composite sine function.

3. The method of claim 2 wherein the frequency domain response, $NF(\omega)$, is

represented by the following equations:

$$NF(\omega) = T, \text{ when } |\omega| \leq \frac{\pi}{T}(1-\alpha)$$

$$NF(\omega) = \frac{T}{2} \left(1 - \sin \left\{ \frac{\pi}{2} \sin \left[\frac{T}{2\alpha} \left(|\omega| - \frac{\pi}{T} \right) \right] \right\} \right), \text{ when } \frac{\pi}{T}(1-\alpha) \leq |\omega| \leq \frac{\pi}{T}(1+\alpha)$$

$$NF(\omega) = 0, \text{ when } \frac{\pi}{T}(1+\alpha) \leq |\omega|$$

20 wherein ω is frequency, T is a time period between symbols, and α is a roll-off factor.

4. The method of claim 2 wherein the frequency domain response (NF) is represented by the following equations:

$$N(\omega) = \begin{cases} T, & \text{when } |\omega| \leq \frac{\pi}{T}(1-\alpha) \\ \frac{T}{2} \left(1 - \sin \left\{ \frac{\pi}{2} \sin \left[\frac{\pi}{2} \sin \left(\frac{T}{2\alpha} \left(|\omega| - \frac{\pi}{T} \right) \right) \right] \right\} \right), & \text{when } \frac{\pi}{T}(1-\alpha) < |\omega| < \frac{\pi}{T}(1+\alpha) \\ 0, & \text{when } \frac{\pi}{T}(1+\alpha) \leq |\omega| \end{cases}$$

5 wherein ω is frequency, T is a time period between symbols, and α is a roll-off factor.

5. The method of claim 1 wherein the frequency domain response is a Nyquist compliant function that when differentiated can be written in the form

$$F'(\omega) = f'(\omega) \cos \left\{ \frac{\pi}{2} \sin \left(\frac{T}{2\alpha} \left(|\omega| - \frac{\pi}{T} \right) \right) \right\} \cos \left[\frac{T}{2\alpha} \left(|\omega| - \frac{\pi}{T} \right) \right]$$

10 wherein ω is frequency, T is a time period between symbols, and α is a roll-off factor.

6. The method of claim 1 wherein the frequency domain response includes a function selected from the group consisting of hyperbolic sines, hyperbolic cosines and polynomials.

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7. The method of claim 1 wherein the frequency domain response is derived by numerical approximations.

8. The method of claim 1 wherein the square root of the frequency domain response has an infinite number of higher order derivatives, each of the infinite number of higher order derivatives being continuous over all points.
- 5 9. An improved Nyquist filter for use as a matched filter in a digital communications system, the filter being characterized in that the frequency domain response meets the Nyquist criteria and that the square root of the frequency domain response has a first derivative that is continuous at all points.
- 10 10. The filter of claim 9 wherein the frequency domain response is a Nyquist compliant function that when differentiated can be written in the form

$$F'(\omega) = f'(\omega) \cos \left\{ \frac{\pi}{2} \sin \left(\frac{T}{2\alpha} \left(|\omega| - \frac{\pi}{T} \right) \right) \right\} \cos \left[\frac{T}{2\alpha} \left(|\omega| - \frac{\pi}{T} \right) \right]$$

wherein ω is frequency, T is a time period between symbols, and α is a roll-off factor.

- 15 11. The filter of claim 9 wherein the frequency domain response, $NF(\omega)$, is represented by the following equations:

$$NF(\omega) = T, \text{ when } |\omega| \leq \frac{\pi}{T}(1-\alpha)$$

$$NF(\omega) = \frac{T}{2} \left(1 - \sin \left\{ \frac{\pi}{2} \sin \left[\frac{T}{2\alpha} \left(|\omega| - \frac{\pi}{T} \right) \right] \right\} \right), \text{ when } \frac{\pi}{T}(1-\alpha) \leq |\omega| \leq \frac{\pi}{T}(1+\alpha)$$

$$NF(\omega) = 0, \text{ when } \frac{\pi}{T}(1+\alpha) \leq |\omega|$$

wherein ω is frequency, T is a time period between symbols, and α is a roll-off factor.

12. The filter of claim 9 wherein the frequency domain response, $NF(\omega)$, is represented by the following equations:

$$N(\omega) = \begin{cases} T, & \text{when } |\omega| \leq \frac{\pi}{T}(1-\alpha) \\ \frac{T}{2} \left(1 - \sin \left\{ \frac{\pi}{2} \sin \left[\frac{\pi}{2} \sin \left(\frac{T}{2\alpha} \left(|\omega| - \frac{\pi}{T} \right) \right) \right] \right\} \right), & \text{when } \frac{\pi}{T}(1-\alpha) < |\omega| < \frac{\pi}{T}(1+\alpha) \\ 0, & \text{when } \frac{\pi}{T}(1+\alpha) \leq |\omega| \end{cases}$$

wherein ω is frequency, T is a time period between symbols, and α is a roll-off factor.

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13. A communication device comprising:

a digital signal source;
a pulse shaping filter coupled to receive digital data from the analog-to-digital converter, the pulse shaping filter being characterized in that the frequency domain response meets the Nyquist criteria and that the square root of the frequency domain response has a first derivative that is continuous at all points, the pulse shaping filter having an impulse response corresponding to the square root of the frequency domain response; and
a modulator coupled to receive a signal from the pulse shaping filter.

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14. The device of claim 13 and further comprising a mapping unit coupled between the digital data source and the pulse shaping filter.

15. The device of claim 14 wherein the mapping unit comprises a quadrature amplitude modulation unit and generates an I stream of data and a Q stream of data, the I

stream of data being input to the pulse shaping filter and the Q stream of data being input to a second pulse shaping filter.

16. The device of claim 14 wherein the mapping unit and the pulse shaping filter are
5 integrated on a single chip.

17. The device of claim 13 wherein the digital data source comprises an analog-to-digital converter.

10 18. The device of claim 13 wherein the pulse shaping filter is implemented with a look-up table stored in a memory array.

19. The device of claim 13 and further comprising a digital-to-analog converter coupled between the pulse shaping filter and the modulator.

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20. The device of claim 13 wherein the frequency domain response is a Nyquist compliant function that when differentiated can be written in the form

$$F'(\omega) = f'(\omega) \cos \left\{ \frac{\pi}{2} \sin \left(\frac{T}{2\alpha} \left(|\omega| - \frac{\pi}{T} \right) \right) \right\} \cos \left[\frac{T}{2\alpha} \left(|\omega| - \frac{\pi}{T} \right) \right]$$

wherein ω is frequency, T is a time period between symbols, and α is a roll-off factor.

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21. A memory device storing a look-up table for an impulse response for a filter, the filter being characterized in that the frequency domain response meets the Nyquist

criteria and that the square root of the frequency domain response has a first derivative that is continuous at all points.

22. The device of claim 21 wherein the frequency domain response is a Nyquist

5 compliant function that when differentiated can be written in the form

$$F'(\omega) = f'(\omega) \cos \left\{ \frac{\pi}{2} \sin \left(\frac{T}{2\alpha} \left(|\omega| - \frac{\pi}{T} \right) \right) \right\} \cos \left[\frac{T}{2\alpha} \left(|\omega| - \frac{\pi}{T} \right) \right]$$

wherein ω is frequency, T is a time period between symbols, and α is a roll-off factor.

23. The device of claim 21 wherein the memory device is integrated on the same

10 integrated circuit as a digital signal processor core.